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Colorado State Univ, Fort Collins Dept of Industrial Sciences

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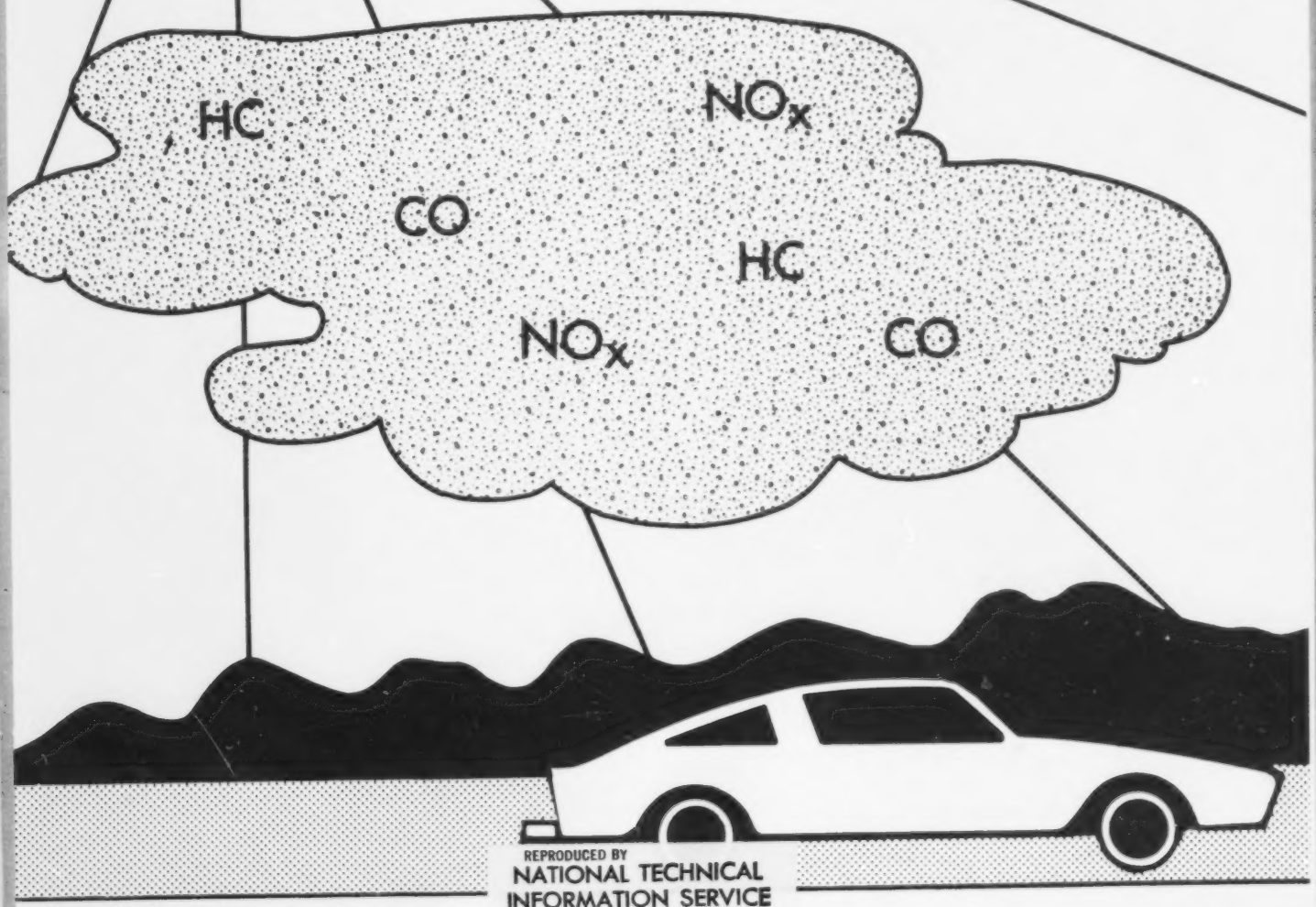
MOTOR VEHICLE EMISSIONS CONTROL BOOK FIVE EXHAUST GAS RECIRCULATION SYSTEMS



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16. ABSTRACT

This book is one of a series designed specifically to teach the concepts of automobile emissions control systems. It is intended to assist the practicing mechanic or the home mechanic to better understand the Exhaust Gas Recirculation Systems which are an integral part of automobiles today. The mechanic's increased knowledge should help him keep "emissions controlled" vehicles operating as designed. Respectable fuel economy, performance and driveability, as well as cleaner air, can be obtained from the automobile engine that has all of its emissions systems functioning properly.

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EXHAUST GAS
RECIRCULATION SYSTEMS

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MOTOR VEHICLE EMISSIONS CONTROL

-- SERIES OF SEVEN BOOKS --

MOTOR VEHICLE EMISSIONS STAFF, COLORADO STATE UNIVERSITY

BOOK ONE - POSITIVE CRANKCASE VENTILATION SYSTEMS

BOOK TWO - THERMOSTATIC AIR CLEANER SYSTEMS

BOOK THREE - AIR INJECTION REACTION SYSTEMS

BOOK FOUR - FUEL EVAPORATION CONTROL SYSTEMS

BOOK FIVE - EXHAUST GAS RECIRCULATION SYSTEMS

BOOK SIX - SPARK CONTROL SYSTEMS

BOOK SEVEN - CATALYTIC CONVERTER SYSTEMS

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A special thanks must be extended to the automotive vehicle equipment and parts manufacturers for their cooperation and assistance in the development of this training material.

INSTRUCTIONS FOR THE USE OF THIS BOOK

This book is one of a series designed specifically to teach the concepts of automobile emissions control systems. Each book is designed to be used as self-instructional material. Therefore, it is important that you follow the step-by-step procedure format so that you may realize the full value of the emissions system which is being presented. The topics are taught in incremental steps and each topic treatment prepares the student for the next topic. Each book is divided into sections which include the introduction, purpose, function, inspection and testing of the emissions system presented.

As you proceed through this series, please begin with book one and read the following books in sequence. This is important because there are several instances where material covered in a given book relies on previously covered material in another book.

To receive the full benefits of the book, please answer the self-evaluation statements related to the material. These statements are separated from the text by solid lines crossing the page. The answers to the statement can be found at the end of the book as identified by the table of contents. You should check for the correct answer after you respond to each statement. If you find that you have made a mistake, go back through the material which relates to the statement or statements.

Fill-in-the-blank statements are utilized for self-evaluation purposes throughout the material. An example statement would appear like this:

The American flag is red, white, and _____.

You would write "blue" in the blank and immediately check your answer at the end of the book.

The material, statements and illustrations should be easy to follow and understand. In several illustrations a small ghost named "VEC" (Vehicle Emissions Control) has been used to make the picture easier to understand.

Upon completion of this scries, you should be able to better understand the emissions control systems and devices which are an integral part of automobiles today. Your increased knowledge should help you keep these "emissions controlled" vehicles operating as they were designed to operate. Respectable fuel economy, performance and driveability, as well as cleaner air, can be obtained from the automobile engine that has all of its emissions systems functioning properly.

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INTRODUCTION TO EMISSIONS CONTROL

As we all know emissions systems and devices have been installed on the automobile engine because of the air pollution problem. In order for you to understand these emissions systems and devices you should have a background of the problem. All of the emissions control systems were installed on the engine to reduce just three specific exhaust products. These are known as products of combustion. The three products which the emissions systems are designed to reduce are hydrocarbons, carbon monoxide and oxides of nitrogen.

HYDROCARBONS

Gasoline, like all petroleum products, is made up of hundreds of hydrocarbon compounds. The name "hydrocarbon" has been given to these compounds because they are made up of hydrogen and carbon atoms. This is also the reason hydrocarbons have the abbreviation (HC).

Hydrocarbons are gasoline vapors or raw gasoline itself. One reason hydrocarbon emissions must be controlled is because it is one of the major components of photochemical smog. Photochemical or "Los Angeles" smog forms when hydrocarbons and oxides of nitrogen combine in the presence of sunlight. In order to avoid this smog condition the hydrocarbon emissions from automobiles must be controlled. Hydrocarbons also act as an irritant to our eyes and some are suspected of causing cancer and other health problems.

CARBON MONOXIDE

Another product of combustion that must be controlled is carbon monoxide. Carbon monoxide has the abbreviation (CO). CO is also hazardous to our health when it is mixed with the air we breathe. It can cause headaches, reduce mental alertness and even cause death if enough of it is in the air. Carbon monoxide is also a problem in that it speeds the formation of photochemical smog. For these reasons CO emissions must be controlled.

OXIDES OF NITROGEN

Oxides of nitrogen are the last harmful products of combustion we will discuss. Nitrogen oxides have been given the abbreviation (NO_x). As you already know, oxides of nitrogen and hydrocarbons combine to form photochemical smog. The sunlight which triggers the formation of photochemical smog has another effect on oxides of nitrogen. Some of the oxides of nitrogen are broken down and a gas called ozone is formed. Ozone is a lung and eye irritant and it also deteriorates rubber and affects the growth of vegetation. Since the nitrogen oxides have these effects they must also be controlled.

Now that you are familiar with the emissions which must be controlled let's find out where they originate.

FORMATION OF HYDROCARBONS

Hydrocarbons, you will recall, are fuel vapors or raw fuel. For this reason hydrocarbon emissions will result from any uncontained supply of gasoline. Hydrocarbon emissions also come from the tailpipe. If the automobile engine could achieve "complete combustion," all of the unburned fuel or hydrocarbons would be used up. However, it is impossible for today's automobile engines to achieve "complete combustion." Any time the fuel mixture in the combustion chamber is not completely burned, some hydrocarbons will be emitted from the tailpipe. The two main reasons why hydrocarbons are not completely burned are because of engine misfire and "quench areas." When an engine misfire occurs, none of the raw fuel or hydrocarbons are burned. When this happens they are simply exhausted directly to the atmosphere. Quench areas are places in the combustion chamber where the flame goes out before the fuel is completely burned. Small cavities such as where the head gasket seals the cylinder head to the block is a quench area. Another quench area is located between the top of the piston and the first compression ring. These areas are sources of hydrocarbon emissions.

FORMATION OF CARBON MONOXIDE

Carbon monoxide is partially burned fuel. Carbon monoxide is formed in the combustion chamber whenever there is not enough air to burn all the fuel. This means that whenever a "rich" air/fuel mixture is pulled into the combustion chamber carbon monoxide will be formed. After the flame goes out the carbon monoxide is exhausted through the tailpipe and into the air.

FORMATION OF OXIDES OF NITROGEN

Oxides of nitrogen are also formed in the combustion chamber. These oxides result from the nitrogen which is contained in our air. In some cases combustion temperatures in the automobile engine can exceed 4500°F. At temperatures above approximately 2500°F, nitrogen oxides will start forming. Therefore, if combustion chamber temperatures exceed 2500°F, oxides of nitrogen will be produced and then exhausted to our atmosphere.

Now that you understand how these emissions are formed in the automobile engine, we will see how changes in ignition timing and carburetor adjustment affect the amount of these pollutants.

As you know, changes in timing and carburetion can have a large effect on how an engine performs. These changes in timing and carburetion also can have drastic effects on the amount of pollutants which are present in the automobile's exhaust. The amount of hydrocarbons, carbon monoxide and oxides of nitrogen which are present in the exhaust gases will vary as timing and carburetion adjustments are changed.

IGNITION TIMING

Prior to emissions controlled automobiles, advancing the spark timing was a common practice. Setting the spark timing this way caused the spark plug to fire before the piston reached top dead center. This advanced spark timing allowed the maximum amount of heat energy to be

exerted on the piston. As a result the best performance and fuel economy could be obtained. Unfortunately, this also produces high hydrocarbon and nitrogen oxide emissions levels.

In order to reduce emissions levels, ignition spark timing was retarded. By firing the spark plug after the piston reaches top dead center, not as much of the heat energy is converted to work on the piston. The extra heat energy which is not used on the piston now passes through the exhaust valve and into the exhaust manifold. This keeps the exhaust gas temperatures higher. These higher exhaust temperatures allow burning of the air/fuel mixture to continue in the exhaust manifold. This further oxidation or burning in the exhaust manifold helps to reduce HC and CO emissions.

Another advantage of retarded timing from an emissions standpoint is that combustion temperatures are not as high. This is due to the fact that the maximum combustion pressure will be lower. Since the combustion temperatures will be lower and the formation of oxides of nitrogen depends on temperature, a smaller amount of these pollutants will be exhausted to the atmosphere.

There is one more advantage to using retarded spark timing. As you know, when ignition timing is retarded the engine's idle speed will drop. This decrease in idle speed occurs because less heat energy is applied to the combustion chamber and more heat energy is being supplied to continue the burning process in the exhaust manifold. In order to regain an acceptable idle speed, the throttle plates must be opened wider. This wider throttle plate opening allows more air to pass through the carburetor. This increase in air flow will reduce the amount of residual exhaust gases in the cylinder. This in turn will allow a more burnable mixture which can be made leaner. Since the mixture can be leaner there will be more air in the combustion chamber. As you know, the more air that is made available during combustion the lower will be the HC and CO emissions.

CARBURETION

Adjustments made to the carburetor air/fuel ratio can also have a large effect on the amount of pollutants which come from the automobile engine. When idle mixture settings become richer there is less air present for the combustion process. This lack of air results in an increase in hydrocarbon and carbon monoxide emissions.

When idle mixture screws are turned in, the amount of fuel is reduced and the mixture becomes leaner. This leaner mixture contains more air and therefore more oxygen is available for more complete burning of the fuel. This results in lower HC and CO emissions levels.

As the idle mixture screws are turned in, the idle air/fuel mixture becomes leaner. If this mixture becomes too lean a "lean misfire" will occur. A "lean misfire" will occur because the fuel is so diluted or thinned out by the air that the mixture will not ignite. This leads to a very large increase in hydrocarbon emissions. This happens because the failure of the mixture to ignite results in that amount of raw fuel being emitted to the atmosphere.

The carbon monoxide emissions decrease when a lean misfire condition is present. Carbon monoxide is partially burned fuel. Since no combustion takes place during a lean misfire condition no CO is formed and the total amount of CO produced by the engine will be less.

A lean misfire usually occurs in one or more cylinders. This condition may also move from cylinder to cylinder while the engine is running. This is caused by the uneven distribution of the air/fuel mixture delivered to each cylinder. This condition occurs mainly because of problems with intake manifold design.

Now you should understand how changes in timing and carburetion adjustment can affect emissions levels. With this knowledge you will be able to understand how each emissions control system we will discuss helps to reduce the air pollution caused by the automobile.

SYSTEM INTRODUCTION

The next emissions control system we will discuss is the Exhaust Gas Recirculation System. The Exhaust Gas Recirculation system is abbreviated EGR system.

The EGR system provides a way to recirculate, or return into the intake manifold, a small portion of the exhaust gases. These exhaust gases are mixed with the fresh, air/fuel mixture. Why mix exhaust gases with a clean air and fuel mixture? Normally we do not expect to find this done in an automobile engine.

FIGURE 5-1

Before we go any deeper into the EGR system, let's go back and review, just a little, on what we know about air and combustion. This review will help you understand why an exhaust gas recirculation system is used.

As you recall, and as VEC is pointing out in figure 5-2, air is made up of about 21% oxygen (O_2), 78% nitrogen (N_2) and 1% of other harmless gases.

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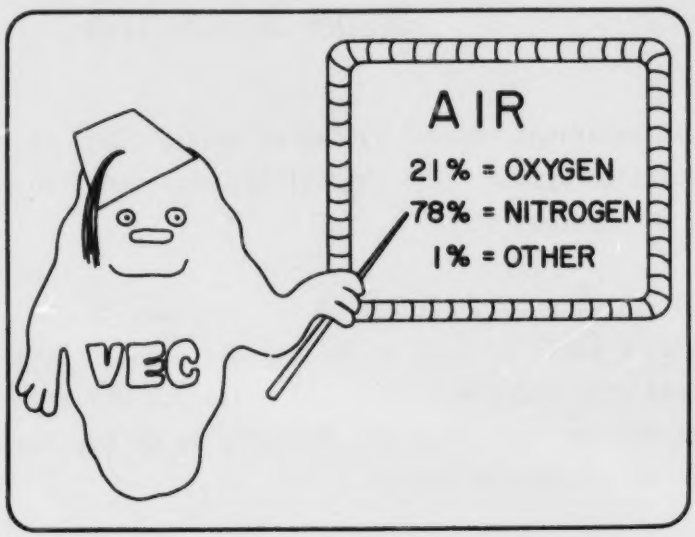

FIGURE 5-2

We need the oxygen, to support the burning of the fuel in the combustion chamber. The nitrogen in the air we normally do not think about. Nitrogen is called an inert gas. By inert, we mean that nitrogen is very stable just the way it is, and does not want to change or combine with any other elements. Now let's see what happens when we take air, mix it with fuel and burn it in the combustion chamber. As we have already mentioned, we use the oxygen in the air to support the burning of the fuel. The nitrogen in the air behaves differently under the high temperatures and pressures of combustion. When the temperature gets above about 2500°F., nitrogen can no longer be called inert.

Under these high temperatures, nitrogen and oxygen are chemically changed and combine to form a variety of gases. These gases containing nitrogen and oxygen are grouped together and given the name oxides of nitrogen or NO_x. As you know NO_x plays a big part in the formation or making of photochemical smog. To help make our air cleaner and reduce some of this trouble with nitrogen, we use the EGR system. Before we see how the EGR system reduces NO_x, let's review some of the main points previously covered.

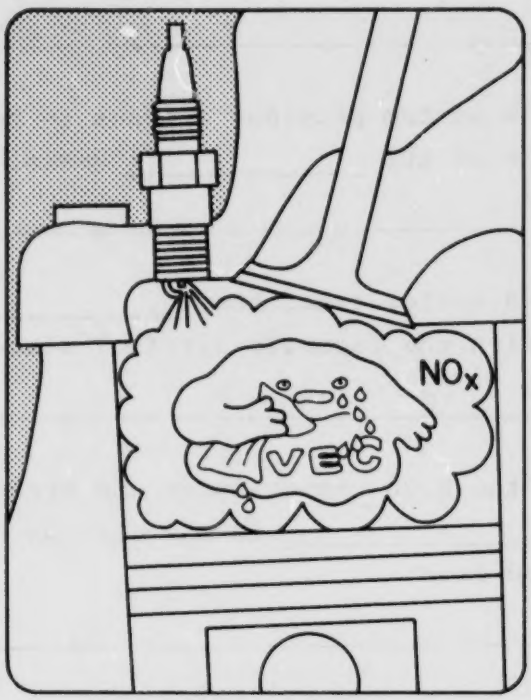

FIGURE 5-3

We know that the exhaust gas is inert. By inert, we mean that nearly 99% of the oxygen and fuel has been burned. If it has been burned once, it cannot support or aid the burning of the fresh air/fuel mixture in the cylinder. This recirculated exhaust gas is mixed with the fresh air/fuel mixture and tends to dilute it or thin it out.

The same is true for the exhaust gas we put in with the fresh air/fuel mixture. The exhaust gas tends to separate or dilute the air/fuel mixture and lower the temperature of the burning process. By lowering the temperature of combustion, less NO_x is formed.

The EGR system was first used on automobiles in 1972. The only state which required this system in 1972 was California. However, in 1973, the EGR system was used on most automobiles sold in the United States. In 1973 Federal Standards limited the amount of NO_x that could be emitted from any automobile. This is why the EGR system can be found on almost all 1973 and newer vehicles.

1. The EGR system provides a means to recirculate a small portion of the _____ gases.

2. The EGR system takes the _____ gases and mixes them with the incoming air/fuel mixture.

3. Under the high temperatures and pressures of combustion the _____ in the air can no longer be considered inert.

4. Nitrogen can no longer be called inert when the temperature gets above about _____.

5. Exhaust gases are gases that have been burned. Since they have been burned once, they cannot burn again. For this reason, we call exhaust gases _____ gases.

6. The exhaust gases which are mixed with the fresh air/fuel mixture tend to dilute the mixture. This dilution results in a _____ temperature when the air/fuel mixture burns.

7. Less _____ will be formed with lower combustion temperatures.

8. EGR is an abbreviation for _____ _____ _____.

SYSTEM/COMPONENT PURPOSE

Now you know basically how the EGR system controlls NO_x emissions. Let's look at the purpose of the EGR system and its components.

The purpose of the EGR system is to recirculate exhaust gases to the intake manifold. The amount of exhaust gas recirculated must be carefully controlled. If too much exhaust gas is supplied at the wrong time, the engine will run very rough and possibly stall. If the EGR system does not recirculate enough exhaust gases, NO_x emissions will not be reduced. For this reason the operation of the EGR valve must be very carefully controlled.

Let's look at an EGR valve, and some of the different parts or components that make up some EGR systems. This will show you how the amount of exhaust gas recirculated is controlled.

THE EGR VALVE

The EGR valve is the center of any EGR system. Its purpose is to regulate or control the amount of exhaust gas to be recirculated. The EGR valve

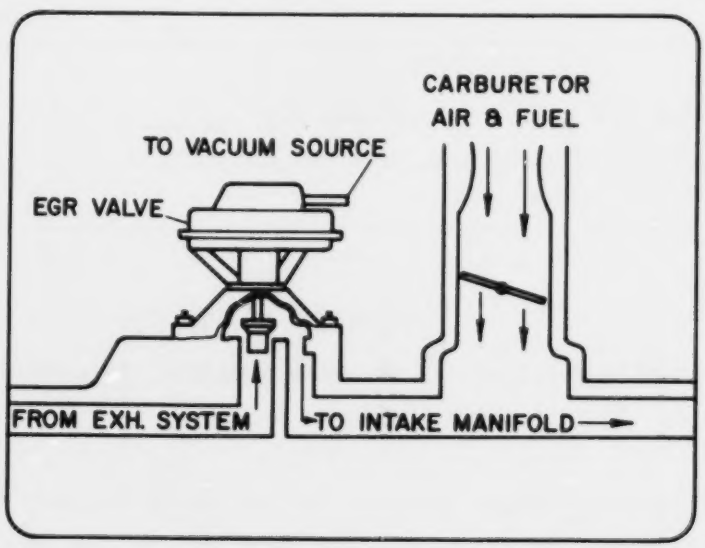

FIGURE 5-4

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is normally bolted to the intake manifold. Directly below the EGR valve there is an opening that leads to the exhaust system. It is from this opening that exhaust gas is allowed to pass to the intake manifold. The only time this exhaust gas is allowed to pass into the intake manifold is when the EGR valve is opened.

The EGR valve is opened by vacuum. This vacuum may come from different places on the engine. It would help us later if we took time now to examine some different sources of vacuum used on today's engines

---

9. The purpose of the EGR system is to mix exhaust gases with the air/fuel mixture in the _____ _____.

---

10. The amount of exhaust gases recirculated to the intake manifold is carefully controlled by the operation of the EGR _____.

---

11. The EGR valve is opened by _____. When this valve is open exhaust gases pass to the intake manifold.

SOURCES OF VACUUM

Intake manifold vacuum, as the name suggests, is common to the intake manifold. This is shown in figure 5-5.

We can consider intake manifold vacuum, to be present from under the throttle plates in the carbuetor, down through the inside of the intake manifold and down to the intake valve for each cylinder. This vacuum

or lack of pressure is caused by the up and down, or pumping, action of the pistons. Ported vacuum is another source of vacuum used for the EGR

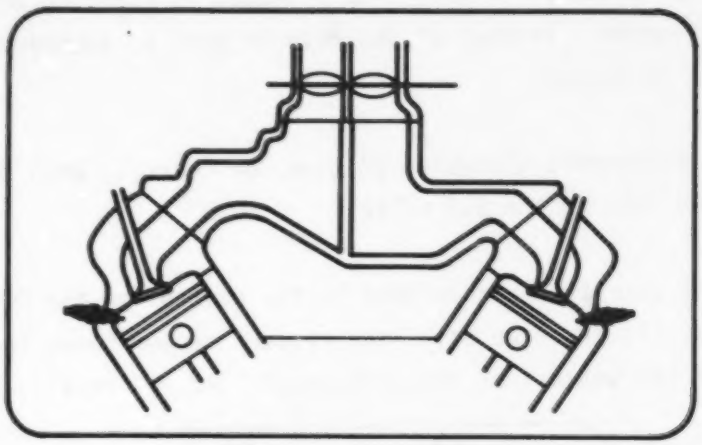

FIGURE 5-5

system. On a ported vacuum system the tapoff, or point where we get this vacuum signal, is located above the throttle plates in the carburetor.

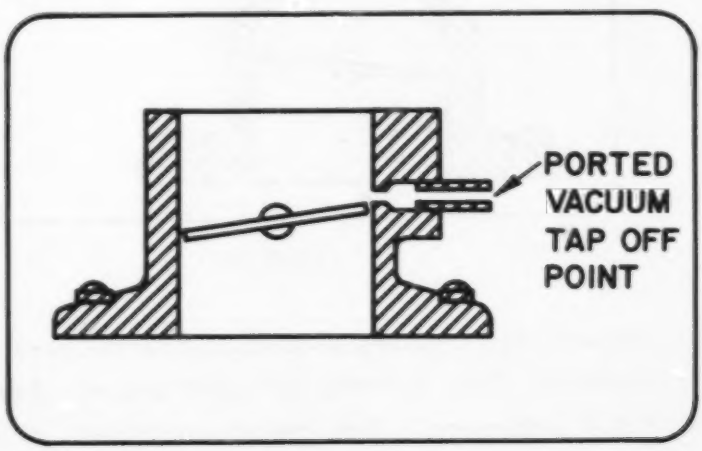

FIGURE 5-6

By locating the tapoff above the throttle plates we can control when the vacuum signal will occur. At idle the throttle plates are nearly closed. As you can see in figure 5-6, in this position the throttle plate is below the tapoff point and no vacuum is present. However, as the throttle begins

to open, the hole or port for the ported vacuum is uncovered. As the hole is uncovered it is exposed to the intake manifold vacuum below the throttle plates. At this time a vacuum is starting to be felt at the tapoff point. As more of the hole or port is uncovered, the amount of vacuum increases.

This arrangement allows us to time, or control, when the vacuum signal will be felt at the EGR valve.

Another source of vacuum used in the control of the EGR valve is venturi vacuum. As the name says, the venturi vacuum comes from a hole, or tap-off in the venturi of the carburetor. As you recall, the speed of the

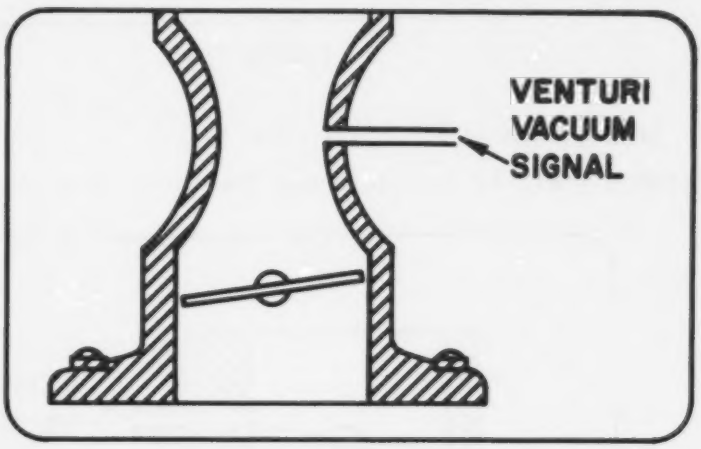

FIGURE 5-7

air must increase as it passes through the narrow area or venturi section of the carburetor. This increase in speed causes a low pressure in this section of the carburetor. This low pressure area, or vacuum is felt at the tapoff point in the venturi. As engine speed increases, air flow through the carburetor increases. This increase in air flow means the speed of the air must also increase. Changes in air speed through the carburetor depend on the speed or RPM of the engine. These changes in venturi vacuum result in a vacuum signal that corresponds to engine speed. At idle, when there is very little air flow, the venturi vacuum would

be zero. As engine speed increases the venturi vacuum also increases. This variable or changing venturi vacuum is used to control some emissions devices.

12. There is ____ vacuum signal at idle with ported vacuum.

13. In a ported vacuum system when the _____ is uncovered, a vacuum signal is felt as engine speed increases.

14. _____ vacuum is another source of vacuum used to control the EGR valve.

15. The venturi vacuum signal would be _____ at idle, when there is very little air flow through the carburetor.

16. The venturi vacuum signal _____ as engine speed increases.

COOLANT TEMPERATURE OVERRIDE SWITCH

Another component or part found in many EGR systems is the coolant temperature override switch. This switch is commonly called the CTO switch. The CTO switch is usually located on the intake manifold. It is threaded

into the intake manifold in a location where it can sense the coolant

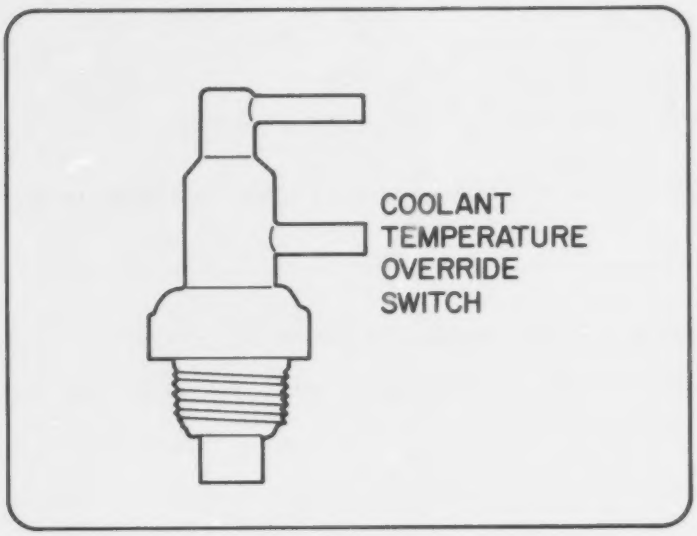

FIGURE 5-8

temperature of the engine. The CTO switch is located between the source of vacuum and the EGR valve. It's purpose is to prevent the vacuum signal from reaching the EGR valve until a certain coolant temperature is reached.

By allowing the engine coolant to warm up before letting the EGR valve operate, the engine performs much better. This improves cold drive-ability and engine performance when it is cold.

AMBIENT TEMPERATURE SWITCH

The ambient temperature switch was used on some EGR systems before March 1973. This temperature switch senses the surrounding air temperature or the ambient temperature. The purpose of the ambient temperature switch is similar to the CTO switch. That purpose is to control the amount of vacuum that reaches the EGR valve below a certain temperature. The ambient temperature switch allows a small amount of air to bleed into the vacuum line that goes to the EGR valve. This small air bleed reduces the amount of vacuum that reaches the EGR valve. If less vacuum reaches the EGR valve, the valve does not open as far. The smaller the opening of the valve, the less exhaust gas recirculation.

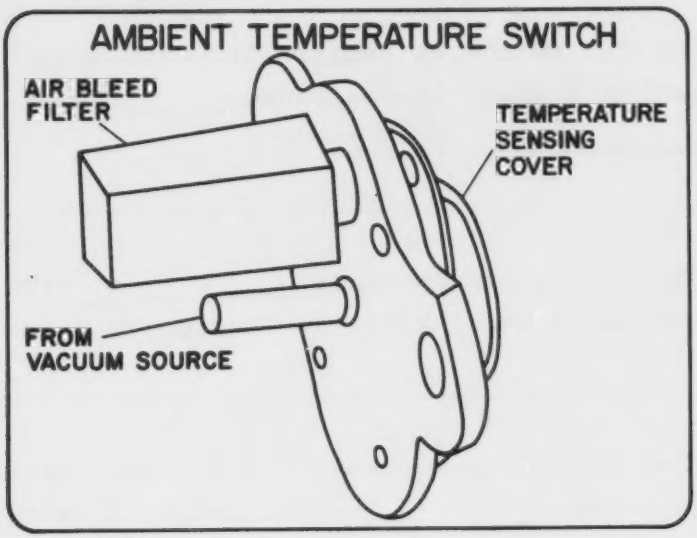

FIGURE 5-9

There are two major differences between at CTO switch and an ambient temperature switch. The first difference is the CTO switch prevents vacuum from reaching the EGR valve. The ambient temperature switch allows a small amount of air to bleed into the EGR valve vacuum line. This air bleed reduces the amount of vacuum that reaches the EGR valve. The second difference is the CTO switch senses coolant temperature. The ambient temperatrue switch is located on the engine compartment firewall and senses ambient air temperature. However, the Environmental Protection Agency (EPA) said that ambient temperature switches could not be used. Ambient temperature switches have not been used since March 1973. Since then, the auto makers have used the CTO switch.

---

17. The _____ _____ _____
switch is another component found in many EGR systems.

---

18. The CTO switch is usually threaded into the intake manifold where it can sense _____ _____.

19. The CTO switch prevents _____ from reaching the EGR valve until a certain temperature is reached.

20. Some EGR systems manufactured before March 15, 1973 used the _____ temperature switch.

VACUUM AMPLIFIER

The vacuum amplifier is another device used to control the EGR valve. The name "vacuum amplifier" is misleading. The word "amplifier" means to make bigger or enlarge. The vacuum amplifier does not make the vacuum larger. The purpose of the vacuum amplifier is to control the EGR valve. It uses intake manifold vacuum to control the EGR valve. But as you know, intake manifold vacuum is high while the engine is idling. If this high vacuum reaches the EGR valve, it would move the valve wide open. This would allow too much exhaust gas to be recirculated at idle and the engine will idle very roughly and possibly stall.

In order to use intake manifold vacuum to control the EGR valve, it must be controlled very carefully. This is the job of the vacuum amplifier. The vacuum amplifier receives a vacuum signal from the carburetor venturi. This venturi vacuum tells the vacuum amplifier how much intake manifold vacuum to send to the EGR valve. As you can see the amplifier does not make the vacuum larger. It merely uses a fairly weak source of vacuum,

venturi vacuum, to control or regulate the amount of intake manifold vacuum going to the EGR valve.

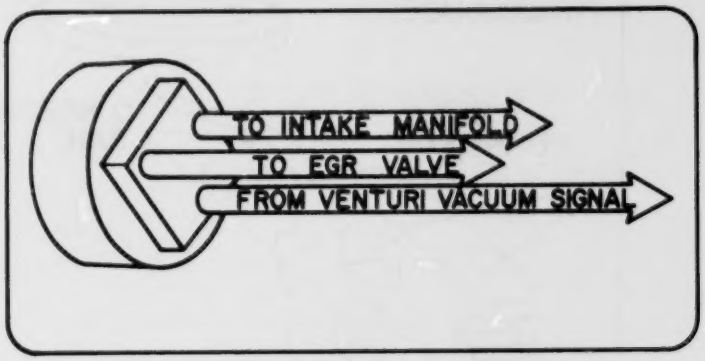

FIGURE 5-10

The vacuum amplifier controls the EGR valve. It does this by using a **vacuum signal** from the carburetor venturi. As engine speed increases, **the venturi** vacuum increases. This signal tells the vacuum amplifier how much intake manifold vacuum to let reach the EGR valve.

EXHAUST BACK PRESSURE SENSOR

The exhaust back pressure sensor is also found on many EGR systems. It is sometimes called an exhaust back pressure transducer. As shown in figure 5-11, there are two basic parts, the sensor and the spacer. The spacer is located under the EGR valve. In the spacer there is a tube or line that senses the exhaust back pressure. This line runs from the spacer to the back pressure sensor. As the name suggests, the back pressure sensor, senses the pressure in the exhaust system. The sensor uses this pressure signal to control the amount of vacuum that reaches the EGR valve. With this device the amount of exhaust gas recirculated depends on the amount of pressure in the exhaust system. The purpose of this device is to improve driveability and fuel economy and still control NO_x emissions.

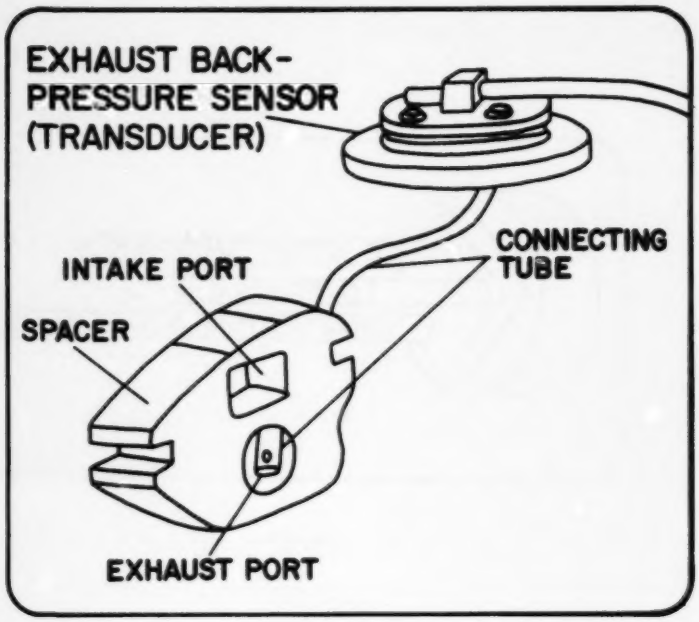

FIGURE 5-11

21. The vacuum amplifier controls the _____ valve operation.

22. The vacuum amplifier controls the EGR valve by using a vacuum signal from the carburetor _____.

23. The venturi vacuum signal increases as engine speed increases. This venturi signal tells the vacuum amplifier how much _____ _____ vacuum to let reach the EGR valve.

24. The exhaust back pressure sensor or transducer senses exhaust _____.

25. The exhaust back pressure signal controls the amount of _____ that reaches the EGR valve.

26. When operating, the amount of exhaust gas recirculated depends on the _____ system pressure.

VACUUM BIAS VALVE

The vacuum bias valve is used by only one manufacturer. It is located between the EGR valve and the vacuum source for the EGR valve. The other side of the vacuum bias valve is connected to intake manifold vacuum.

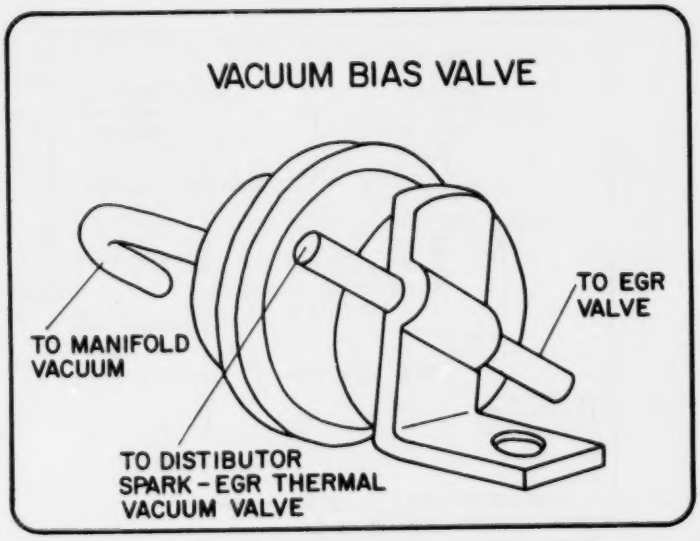

FIGURE 5-12

Anytime that a high intake manifold vacuum is present, the amount of vacuum going to the EGR valve is reduced. This high intake manifold vacuum condition is present during engine idle. It is also present during normal highway driving or cruise conditions. During these conditions the amount of exhaust gas recirculated is reduced. This prevents engine surge during these operating conditions. However, during acceleration, intake manifold vacuum drops. This drop or decrease in intake manifold vacuum allows more exhaust gas to be recirculated during this time. The purpose of the vacuum bias valve is to reduce engine surge. This problem occurs at times when intake manifold vacuum is high such as engine idle or during highway cruise conditions.

EGR DELAY TIMER

Another method that is used to control the EGR valve is the EGR Delay Timer. The purpose of this system is to prevent exhaust gas recirculation for a short period of time after the engine is started. The EGR Delay Timer is made up of two major parts, a vacuum solenoid and the EGR timer control. The vacuum solenoid is located in the ventrui vacuum sensing line between the venturi vacuum tapoff point and the vacuum amplifier. The vacuum solenoid is controlled by the EGR timer control. The timer control unit is located on the firewall.

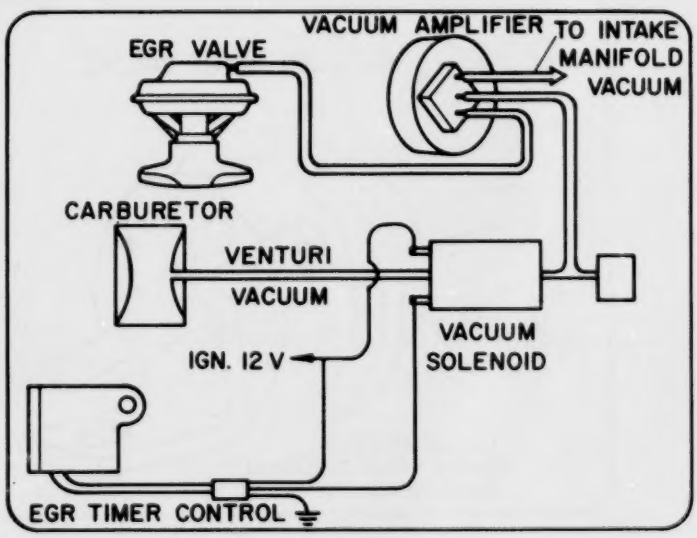

FIGURE 5-13

When the ignition key is turned on the vacuum solenoid is energized. Vacuum is prevented from reaching the vacuum amplifier when the solenoid is energized. After approximately 35 seconds the EGR timer control de-energizes the vacuum solenoid. This allows the venturi vacuum to reach the vacuum amplidier and allow normal EGR operation.

The 35 second delay allows the engine to be started and run for several seconds before the EGR system begins to operate. This setup allows for better cold engine operation after initial engine start up.

Now that we have looked at some of the means or devices used to control and operate the EGR valve, let's put all of this together and look at some EGR systems. The devices we just talked about will allow us to examine some complete EGR systems. We will be able to see how many of these devices operate to control exactly when the EGR valve will operate and how the amount of exhaust gas recirculated is controlled.

27. The vacuum bias valve is used to reduce engine _____.

28. Engine surge occurs at times when intake manifold vacuum is _____ such as engine idle, and during highway cruise conditions.

29. The purpose of the EGR delay timer is to _____ exhaust gas recirculation for a short time after the engine is started.

30. The EGR delay timer prevents EGR valve operation for approximately ____ seconds after the ignition key is turned on.

31. Vacuum is prevented from reaching the vacuum amplifier by a _____ _____.

32. The vacuum solenoid is energized and de-energized by the EGR _____ _____.

SYSTEM/COMPONENT FUNCTION

The first component you will look at is the EGR valve. You will look at the parts that make up an EGR valve and what function these parts play in the operation of the EGR valve.

EGR VALVE

Figure 5-14 shows a typical EGR valve. The main parts of the EGR valve are the diaphragm spring, the diaphragm, the pintle or valve and the pintle or valve seat.

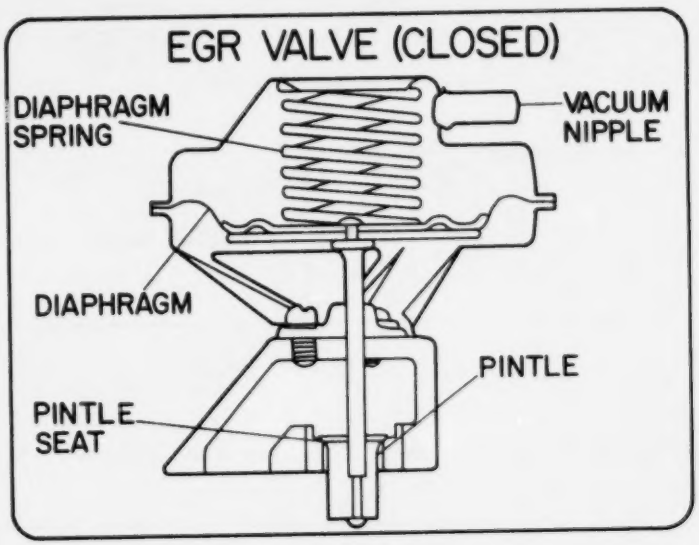

FIGURE 5-14

The diaphragm spring pushes down against the diaphragm. This downward push or force of the spring holds the pintle or valve in its normally closed position. In the closed position, the pintle or valve rests on the pintle or valve seat. In this position, no exhaust gas can be recirculated or mixed with the air/fuel mixture.

The area above the diaphragm, where the diaphragm spring is located, is a sealed chamber. Coming out of this sealed chamber is a connection for a vacuum hose.

As shown in figure 5-15, when vacuum from a vacuum source is allowed to reach this chamber, the EGR valve begins to open. As the valve or pintle is lifted off its seat exhaust gases are allowed to flow from the exhaust passage into the intake manifold. It normally takes between 3 to 5 inches of vacuum to start opening an EGR valve.

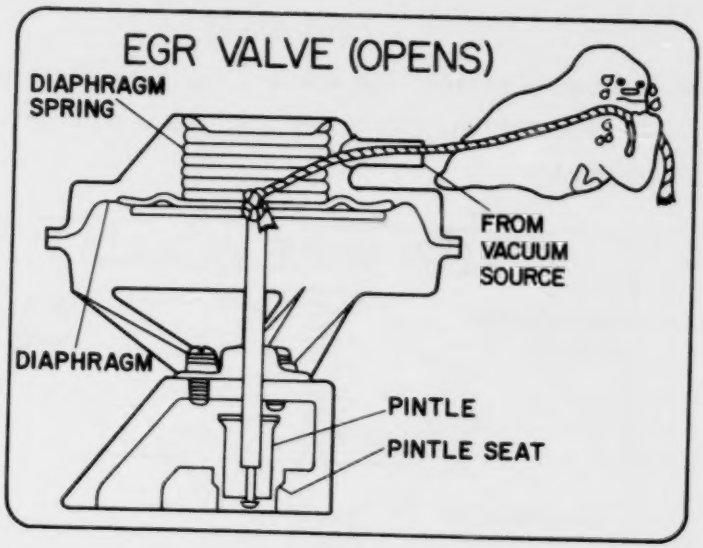

FIGURE 5-15

Many EGR valves look very much alike on the outside. Most EGR valves

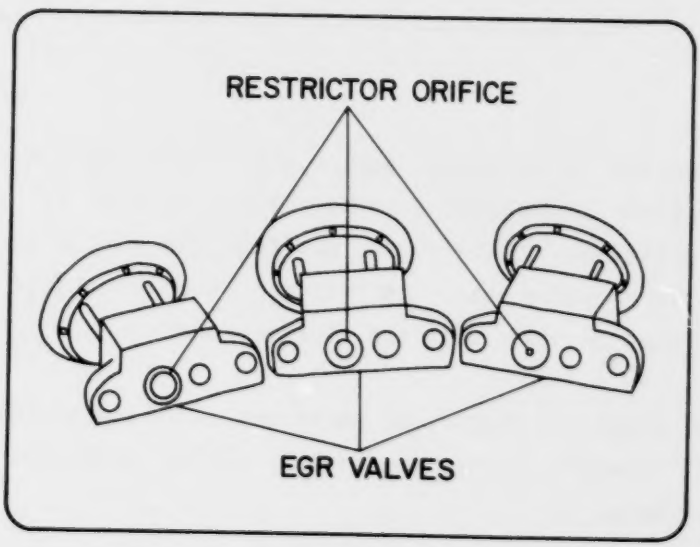

FIGURE 5-16

however, are made differently on the inside. If we look at figure 5-16 one of these differences can be seen. The difference between these valves is in the size of the opening in the bottom of the EGR valve. This opening or restrictor orifice limits the amount of exhaust gas that can be recirculated. By changing the size of the restrictor orifice, the same basic valve can be used for many different engines. The restrictor orifice size is varied by the manufacturer so it can be used on a particular engine. So even though the valves look identical on the outside, be sure to use the correct part number for the car you are working on. This will insure you are using a valve with the proper size restriction orifice for that particular engine.

33. The EGR valve is _____ when it is in the normal position.

34. The EGR valve is held in this closed position by a _____.

35. In this closed position the _____ or pintle is pushed down against the seat. This prevents exhaust gas from being recirculated.

36. When the EGR valve is in this closed position, no exhaust gas can be recirculated or mixed with the _____ mixture.

37. The area above the diaphragm, where the diaphragm spring is located is a _____ chamber.

DUAL DIAPHRAGM EGR VALVE

Another type of EGR valve is the "dual diaphragm" valve shown in figure 5-17. The dual diaphragm EGR valve is recognized by two vacuum hose

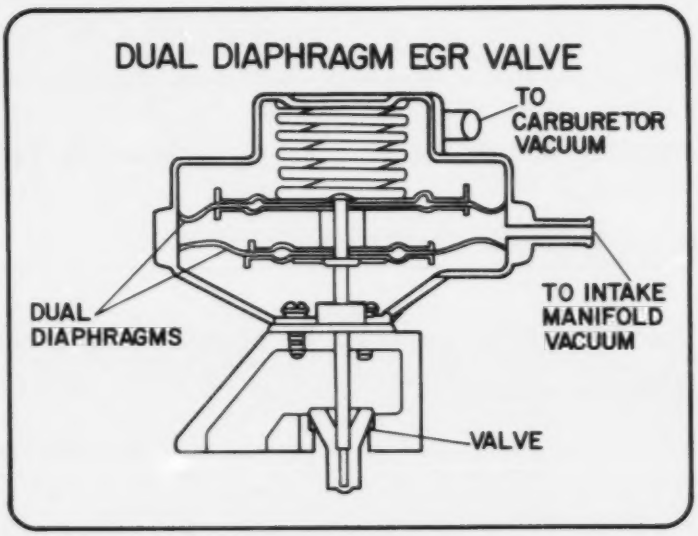

FIGURE 5-17

connections. As you recall, the other EGR valve we have discussed has only one vacuum hose connection. The dual diaphragm valve, as its name suggests, has two diaphragms instead of one. The upper chamber has a connection for carburetor ported vacuum. The lower chamber has a connection for intake manifold vacuum. Carburetor ported vacuum acts on the upper diaphragm to open the EGR valve. During high intake manifold conditions with low engine loads, such as highway cruise, intake manifold vacuum works against ported vacuum. This high intake manifold vacuum

pulls the EGR valve towards the closed position. This closing down of the EGR valve limits the amount of exhaust gas recirculation during cruise conditions.

During acceleration, intake manifold vacuum drops as the engine load increases. This drop or decrease in intake manifold vacuum allows the carburetor ported vacuum to open the EGR valve further. This allows more exhaust gas recirculation to occur during acceleration. This is necessary because when the engine loads are greatest, more NO_x is formed.

38. A dual diaphragm EGR valve can be recognized by _____ vacuum hose connections.

39. The upper chamber of a dual diaphragm EGR valve has a connection for _____ ported vacuum.

40. The lower chamber of a dual diaphragm EGR valve has a connection for _____ _____ vacuum.

41. During high intake manifold conditions (low engine load) such as highway cruise, intake manifold vacuum works against _____ vacuum in the dual diaphragm EGR valve.

42. The dual diaphragm EGR valve allows more exhaust gas recirculation during _____.

43. This extra EGR during acceleration is necessary because _____ formation is greatest during heavy engine loads.

PORTED VACUUM EGR SYSTEM

The ported vacuum EGR system is made up of three components, the EGR valve, the coolant temperature override (CTO) switch, and a ported vacuum tapoff in the carburetor. The ported vacuum tap in the carburetor is located above the carburetor throttle plates.

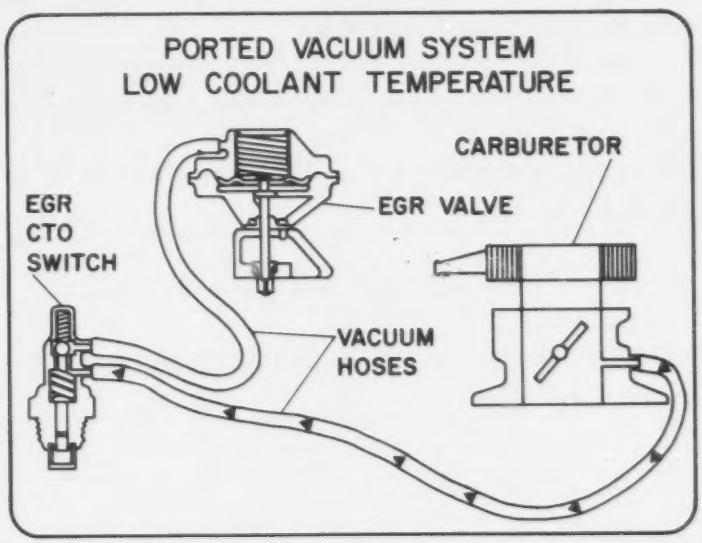

FIGURE 5-18

As you recall, this port location above the throttle plates only allows vacuum to the EGR valve when the throttle is opened. Let's look at the way the ported vacuum system works. We will begin from a cold start condition. Remember the CTO switch is located in a place where it can sense the temperature of the engine coolant. When a cold engine is started the CTO switch prevents vacuum from reaching the EGR valve. In

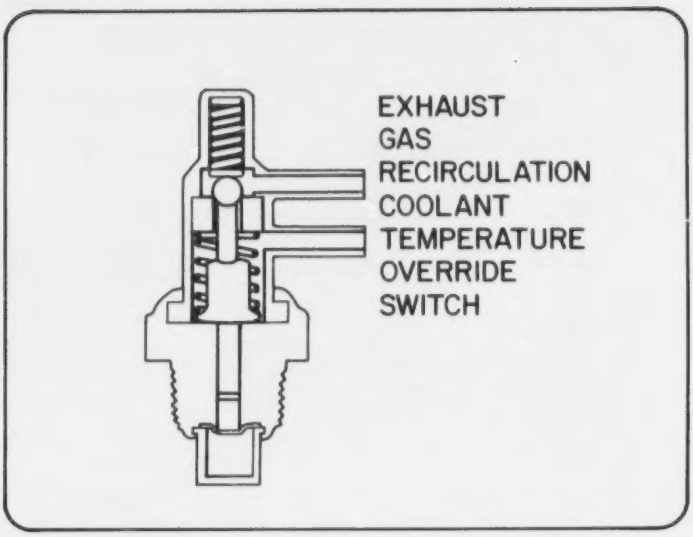

FIGURE 5-19

the CTO switch a ball valve, shown in figure 5-19, is forced down by a spring. In this position the ball blocks the path of ported vacuum to the EGR valve. This prevents the EGR valve from operating when the throttle is opened.

As the engine coolant temperature increases, the CTO switch senses the increase in temperature. At a certain temperature the ball valve is forced upward. The exact temperature varies with the make of car, the year of the car, and the engine used in that vehicle. As the ball valve moves upward it opens the path from the carburetor to the EGR valve.

As the throttle is opened, the ported vacuum tap in the carburetor is uncovered. This allows the ported vacuum to go from the carburetor, to the now open CTO switch and to the EGR valve. You can see this in figure 5-20. The vacuum signal can now act on the EGR valve diaphragm and the EGR valve begins to open, allowing exhaust gas to be recirculated. With the ported vacuum system, when the throttle plates are wide open, no exhaust gas recirculation takes place.

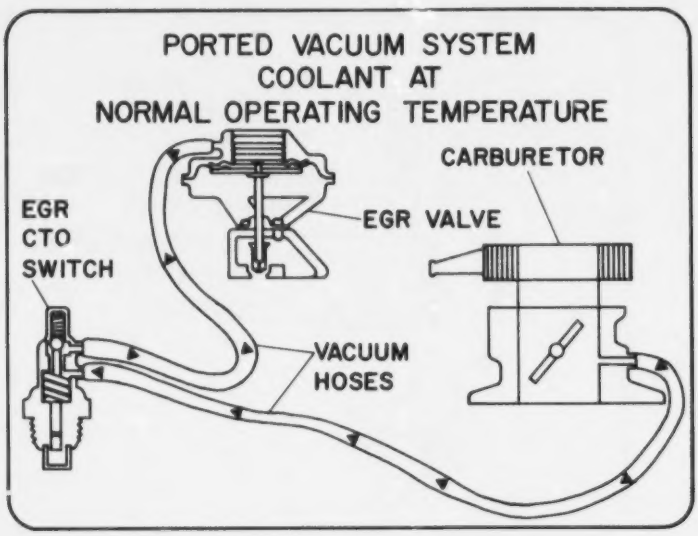

FIGURE 5-20

You will recall that it takes between 3 to 5 inches of vacuum to start opening an EGR valve. During wide open throttle operation intake manifold vacuum will be below this value. So at wide open throttle, the EGR valve is closed by spring pressure.

---

44. When coolant temperature is above the specified value, the _____ in the CTO switch moves up and allows a path for ported vacuum to reach the EGR valve.

---

45. A ported vacuum signal will reach the EGR valve when the throttle is _____.

Now that the ported vacuum system is understood let's look at another type of system: The venturi vacuum EGR system.

VENTURI VACUUM EGR SYSTEM

The venturi vacuum EGR system is made up of four major parts. These are the EGR valve, a vacuum amplifier, a CTO switch and the venturi vacuum tap on the carburetor. Let's look at the events that make this

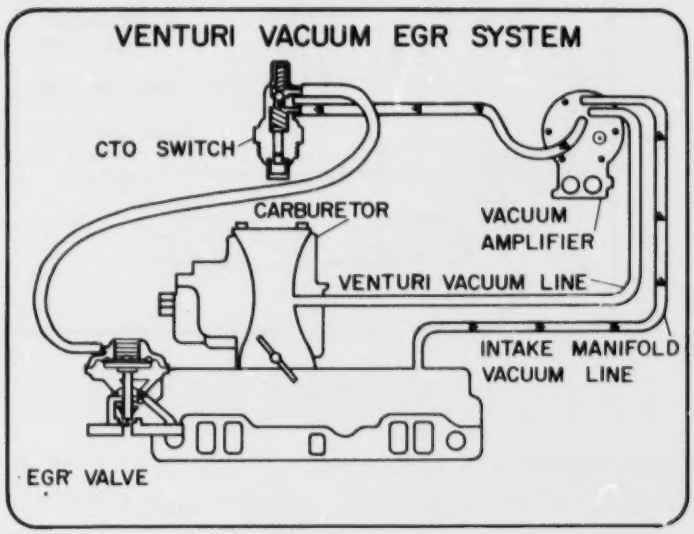

FIGURE 5-21

type of EGR system operate. When the engine is started there is a continuous flow of air through the carburetor. As the engine is accelerated this air flow increases. This increase in air flow means the speed of the air must also increase. As the speed of the air increases, a vacuum is created in the venturi vacuum signal line that goes to the vacuum amplifier. The vacuum amplifier also has a manifold vacuum line connected to it and one other line that goes to the CTO switch. At idle the air flow and speed are very low and no venturi vacuum signal is sent to the vacuum amplifier. As engine speed increases a weak venturi vacuum reaches the vacuum amplifier. This venturi vacuum signal tells the vacuum amplifier how much intake manifold vacuum should be allowed to the CTO switch and the EGR valve. If the engine coolant temperature is below what the CTO switch operates at, vacuum is prevented from reaching the EGR valve. If coolant temperature is above what the CTO switch operates at, vacuum is allowed to the EGR valve.

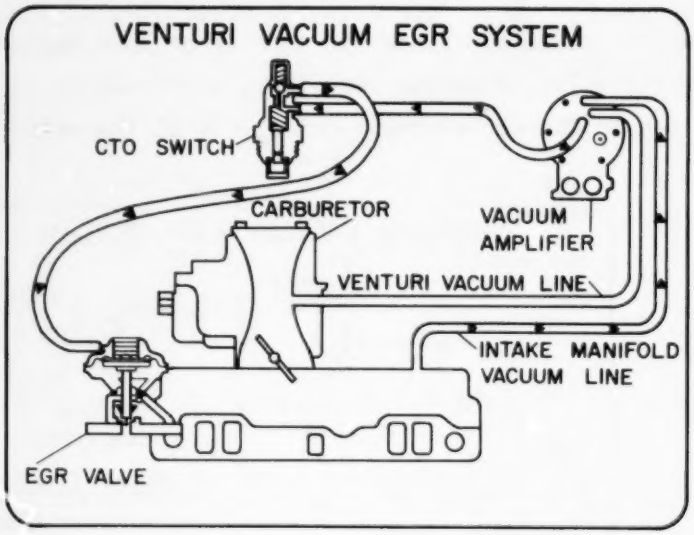

FIGURE 5-22

When vacuum reaches the EGR valve, it begins to open and allows exhaust gas recirculation to occur. The venturi vacuum EGR system is similar to the ported vacuum system in that it does not allow exhaust gas recirculation to take place at wide open or full throttle conditions. At full throttle, there is a large amount of air flowing through the carburetor venturi. This large amount of air is traveling at a very high speed. This high speed results in a very high venturi vacuum signal. But as you recall, intake manifold vacuum drops to a very low valve during full throttle operation. The vacuum amplifier compares the high venturi vacuum to the low intake manifold vacuum. The vacuum amplifier then limits intake manifold vacuum to the EGR valve. Intake manifold vacuum is limited to a value less than the amount of vacuum needed to open the EGR valve. This prevents exhaust gas recirculation during wide open throttle.

---

46. The venturi vacuum signal tells the vacuum amplifier how much _____ _____ vacuum to apply to the EGR valve.

The next EGR system we will look at will be a ported vacuum system with a back pressure sensor.

BACK PRESSURE SENSOR EGR SYSTEM

The ported vacuum EGR system with an exhaust back pressure sensor has five major components. These may be seen in figure 5-23. These components are the EGR valve, a spacer under the EGR valve, an exhaust back pressure sensor, a CTO switch, and a ported vacuum tapoff on the carburetor.

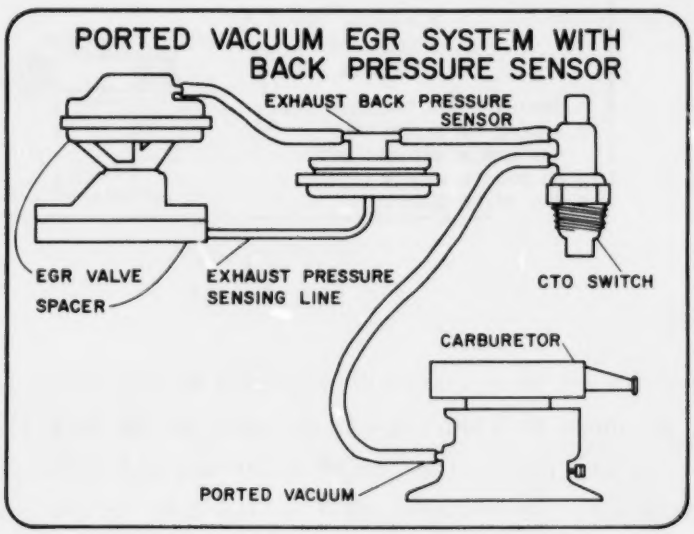

FIGURE 5-23

Except for the exhaust back pressure sensor, the other parts are similar to the ported vacuum EGR system. A cutaway view of the back pressure sensor and spacer is shown in figure 5-24. Exhaust pressure is sensed from a hole in the adaptor. This pressure signal travels through a tube to the sensor or transducer. Inside the transducer is a flexible diaphragm that exhaust pressure pushes against. If exhaust pressure is not strong enough to overcome the spring that is pushing down on the diaphragm, the air bleed hole remains open. The air bleed hole allows air to be drawn into the vacuum line when the diaphragm is in the lower position. An air filter is used in the sensor. This filter removes dirt and dust from the air that is being drawn into the vacuum line. Let's look at

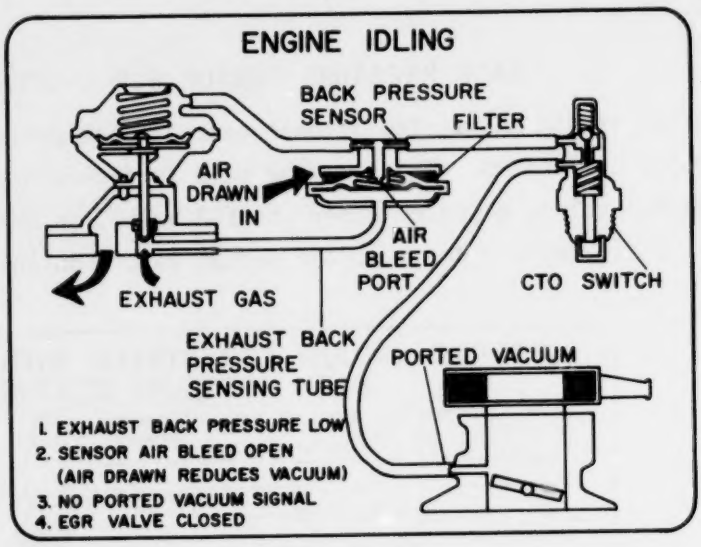

FIGURE 5-24

the operation of this system during idle or low speed (light load) conditions. As shown in figure 5-24, exhaust system back pressure is sensed from a hole drilled in the spacer under the EGR valve. The exhaust system pressure signal travels through a hollow tube to the pressure sensor or transducer. At idle or during a light load condition exhaust back pressure is low. The exhaust signal at the back pressure sensor is also low. This signal is too low to overcome the spring pressure that is pushing down on the sensor diaphragm. This is shown in figure 5-24. With the diaphragm being pushed down by the spring the air bleed hole is open. This allows air to bleed into the vacuum line going to the EGR valve. The air being bled into the vacuum line reduces the vacuum going to the EGR valve. The reduced vacuum is not strong enough to overcome the EGR valve spring pressure and the EGR valve is held shut. No exhaust gas recirculation occurs.

As the load on the engine is increased, such as during part throttle acceleration, exhaust back pressure increases. This increase in exhaust back

pressure is felt on the bottom of the back pressure sensor diaphragm. This condition is shown in figure 5-25. The increased exhaust pressure overcomes spring tension and pushes the diaphragm up. This upward movement of the diaphragm closes off the air bleed hole. With the air bleed hole closed off, no air can enter the vacuum line to the EGR valve. This condition allows the ported vacuum signal from the carburetor to reach the EGR valve. Now the vacuum that reaches the EGR valve is strong enough to overcome the EGR valve spring and open the valve. Exhaust gas recirculation now takes place.

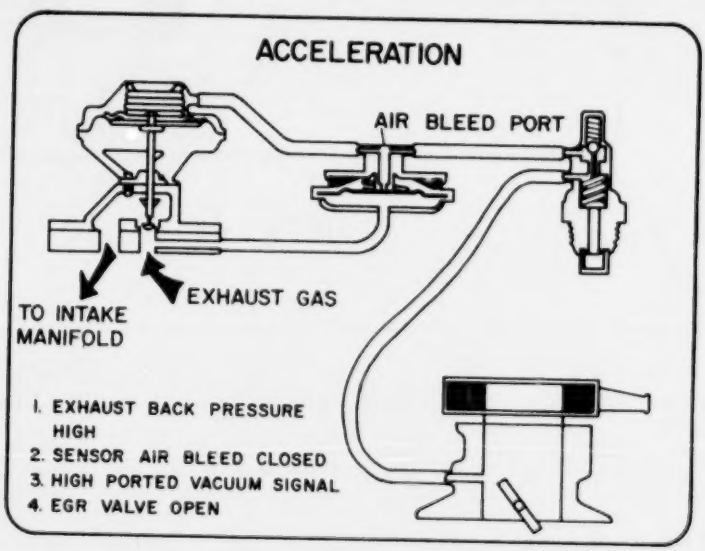

FIGURE 5-25

Under wide open throttle, heavy load conditions, exhaust back pressure is very high. This high exhaust pressure forces the diaphragm against the air bleed hole in the back pressure sensor. With the air bleed hole blocked, no air can enter the vacuum line going to the EGR valve. However, during full throttle operation intake manifold vacuum and ported vacuum will be very low. The ported vacuum signal will be so low that the EGR valve spring will close the EGR valve. There is no exhaust gas recirculation during full throttle with this system as shown in figure 5-26.

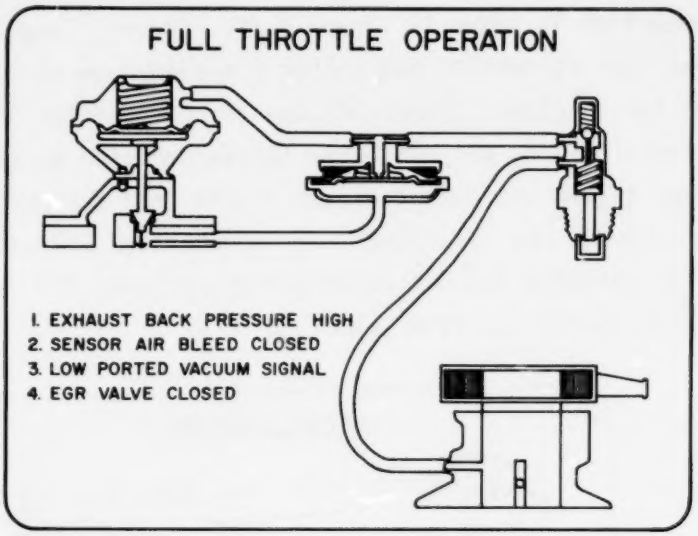
FULL THROTTLE OPERATION
1. EXHAUST BACK PRESSURE HIGH
2. SENSOR AIR BLEED CLOSED
3. LOW PORTED VACUUM SIGNAL
4. EGR VALVE CLOSED

FIGURE 5-26

47. During acceleration, exhaust back pressure is _____.

48. The exhaust gas recirculation system that uses the exhaust back pressure sensor is very similar to the _____ _____ EGR system.

FLOOR JET EGR SYSTEM

The last EGR system we will look at is the Floor Jet EGR System. This system is called the floor jet EGR system because of the location of the jets. The jets are located in the floor of the intake manifold. See figure 5-27. These floor jets allow a metered passage for exhaust gases to flow from the exhaust crossover passage to the intake side of the

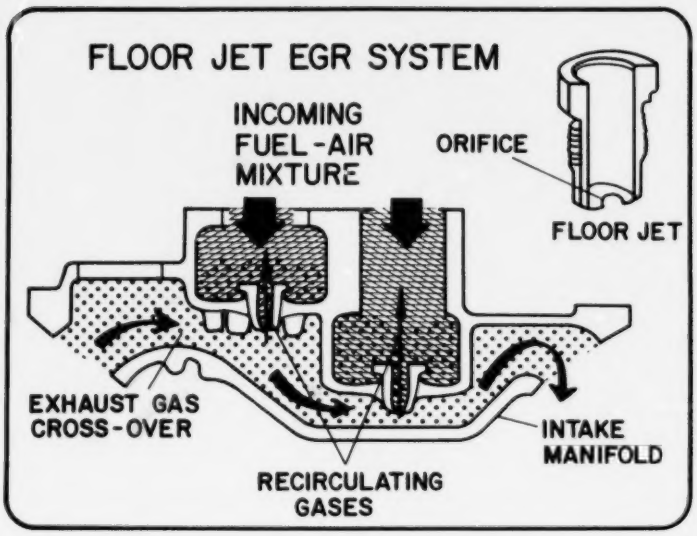

FIGURE 5-27

manifold. Intake manifold vacuum continually draws exhaust gases into the intake manifold. With this system exhaust gas recirculation occurs during idle, cruise and wide open throttle conditions. This system was used by one manufacturer and only for 1973 models.

SYSTEM INSPECTION

A visual inspection is important to insure the proper operation of the EGR system. A visual inspection of hoses and components should be done periodically. This inspection should take place before any testing of the system is done. Inspection requires no tools or instruments and takes only a few minutes. Many problems can be avoided or corrected by following these steps.

1. Obtain a good technical manual or the manufacturer's service manual. Use this to locate a vacuum circuit diagram for the vehicle you are going to inspect.

FIGURE 5-28

There are many different types of EGR systems. These systems may have different components in them. In order to do a thorough inspection a good manual should be used. A good manual will have vacuum circuits in it. These circuits show what components you can expect to find on each make and model of car as well as the components on different engine sizes.

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1. Visually inspect the EGR system. Use the vacuum circuit diagram to insure all the parts or components that are required on the vehicle you are inspecting are installed.

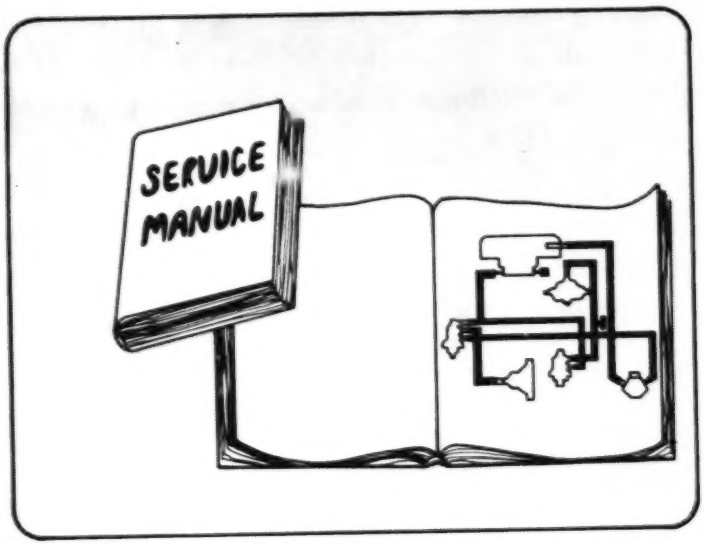

FIGURE 5-29

Each car and engine combination has an EGR system designed for it. This system was designed to keep NO_x emissions at or below federal standards. In addition to emissions, the system was designed to insure the driveability of the car would be acceptable. All the system components must be installed to insure the proper operation of the EGR system.

3. Using the vacuum circuit diagram, check for proper hose routing between the EGR system components.

There are many types of EGR systems; some have up to five or six components. The proper hook-up or connection of these components requires many vacuum hoses. Proper hose routing and the right connections are very important to the proper operation of the EGR

system. The best way to check for the proper routing of hoses and connections is to use a vacuum circuit diagram to insure the connections are correct.

4. Inspect all vacuum lines for cracks, loose connections, or excessive hardness.

   Vacuum lines, being located in the engine compartment, are subjected to a large amount of heat from the engine. This heat causes these vacuum hoses to become brittle or hard. When a vacuum hose becomes brittle or hard, it only takes a small push to crack the hose. This leads to a vacuum leak that can effect engine performance and EGR system operation. Each connection should be checked to make sure the vacuum hose fits snugly. If the hose does not fit snugly on the connection there is a very good chance for a vacuum leak to occur. Any vacuum leak can effect engine performance and cause the EGR system to operate improperly.

A good visual inspection should only take about ten minutes. This inspection could show points where trouble might occur and could solve some problems quickly.

---

49. Inspection of the EGR system should take place before any _____ of the system is done.

---

50. Obtain a good technical manual or the manufacturer's _____ _____.

---

51. Using the _____ circuit diagram, check for proper hose routing between the EGR system components.

SYSTEM TESTING

The purpose of testing the EGR system is to insure it is working properly. EGR systems should be inspected and tested any time the vehicle is being tuned or when the EGR system is suspected of not operating properly. We will begin the testing with a ported vacuum EGR system with a CTO switch.

TESTING THE PORTED VACUUM EGR SYSTEM

To test the complete ported vacuum EGR system at one time the following steps should be followed.

1. Start with a cold engine.
2. Start the engine and slowly increase engine speed to approximately 2000 RPM.
3. While increasing engine speed watch the stem on the EGR valve. The EGR valve stem should not move and the valve should remain closed. If the EGR valve opens when the engine is cold, the CTO switch is defective and should be replaced. Remember, the purpose of the CTO switch is to prevent vacuum from reaching the EGR valve until the coolant temperature reaches a certain temperature. The exact temperature the CTO switch should operate at can be found in a technical manual or the manufacturer's service manual.
4. Allow the engine to warm up to operating temperature.
5. Increase engine speed to approximately 2000 RPM.
6. While increasing engine speed, watch the EGR valve stem. The EGR valve stem should move in the upward direction. This test with the warm engine verifies that the CTO switch did operate and allow vacuum to reach the EGR valve. If the EGR valve does not open during this test the following steps should be taken.
7. Disconnect the vacuum line on the lower connection of the CTO switch. This vacuum line runs from the ported vacuum connection on the carburetor to the CTO switch.

Connect a vacuum gauge to the CTO switch end of the vacuum line.

8. Increase engine speed to 2000 RPM while watching the vacuum gauge. If no vacuum reading shows on the vacuum gauge, the signal ports in the carburetor could be plugged or the vacuum line between the carburetor and the CTO switch could be plugged. Determine which is the fault and correct the problem.

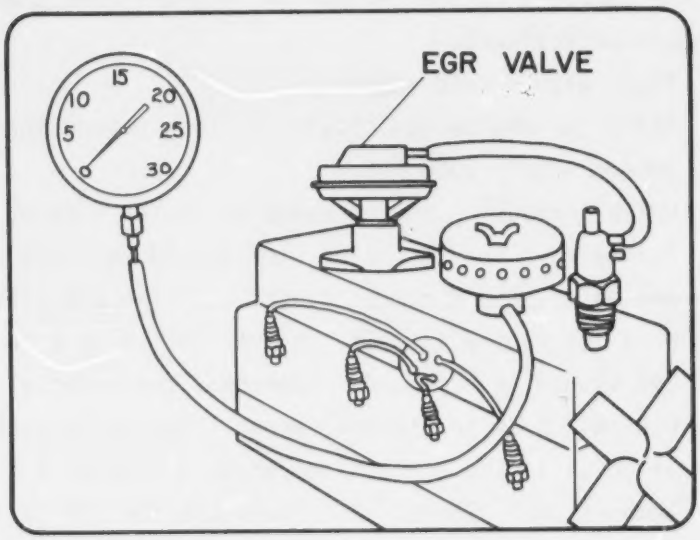

FIGURE 5-30

if a vacuum reading does show on the gauge, this verifies that vacuum is available to the CTO switch.

9. Remove the vacuum gauge from the vacuum line and reinstall the vacuum line on the CTO switch.
10. Remove the vacuum line at the EGR valve and connect the vacuum gauge to this line.
11. Increase engine speed to 2000 RPM and observe the vacuum gauge. If reading appears on the vacuum gauge, this verifies that the CTO switch has opened and is allowing vacuum to the EGR valve. If no

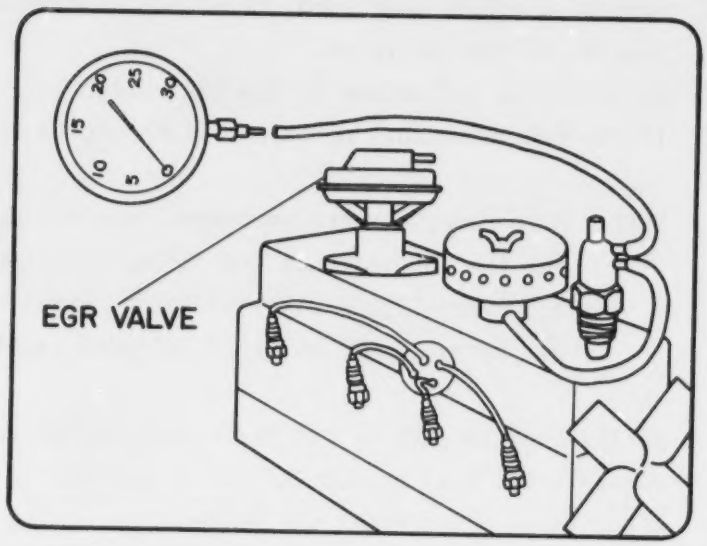

FIGURE 5-31

vacuum reading appears on the gauge the CTO switch is not operating properly and should be replaced. If the CTO is operating properly and allowing vacuum to the EGR valve, the following steps should be taken.

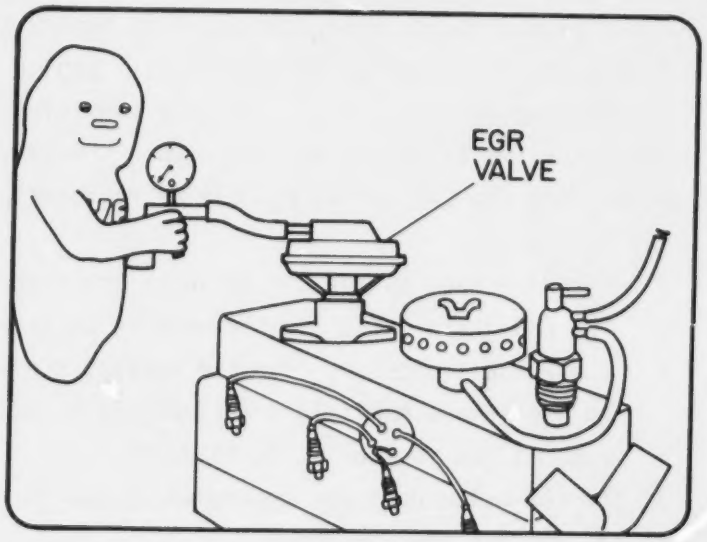

FIGURE 5-32

12. Connect a vacuum hand pump, or an intake manifold vacuum source, to the EGR valve.
13. Apply 12"-16" of vacuum to the EGR valve.
14. If the EGR valve does not open, it should be replaced.

NOTE: Most manufacturers recommend removing and inspecting the EGR valve at the following intervals.
a. Every 12,000 miles if leaded gasoline is used.
b. Every 25,000 miles if unleaded gasoline is used.

If this maintenance is not performed, carbon and/or lead deposits build up around the valve seat and valve. These deposits could prevent the valve from closing completely or keep it from opening.

The next procedure can be used to check all EGR valves, no matter what type of system is used to operate them.

1. Start the engine and allow it to come to operating temperature.
2. Disconnect the vacuum line at the EGR valve.
3. Connect a hand vacuum pump to the EGR valve.
4. Apply vacuum to the EGR valve until it begins to open. As the EGR valve opens, the engine will begine to idle roughly and may even stall. If this condition occurs as the EGR valve is opened and stops when the vacuum is removed from the EGR valve, you can be reasonably sure of the following:
   a. The diaphragm in the EGR valve is not leaking.
   b. The EGR valve seats tightly when it is closed.
   c. The exhaust passages from the exhaust crossover on the intake manifold are clear and allowing exhaust gas recirculation to occur.

   If the EGR valve does not open when vacuum is applied to it, replace the EGR valve.

TESTING THE VENTURI VACUUM EGR SYSTEM

The following procedure can be used to test the venturi vacuum EGR system.

1. Start with a cold engine.
2. Disconnect the venturi vacuum signal hose from the carburetor.
3. Connect a hand vacuum pump to the venturi vacuum line.
4. Start the engine and apply 1"-3" of vacuum to the venturi vacuum sensing line.
5. Watch the EGR valve stem while applying the vacuum. The valve stem should not move.
6. Release the 1"-3" of vacuum. If the valve begins to open while the engine is cold the CTO switch is not operating properly and should be replaced.

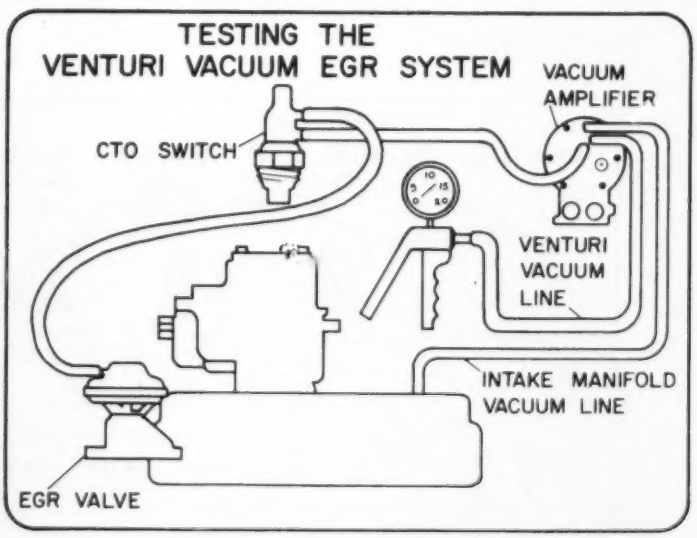

FIGURE 5-33

7. Allow the engine to come to normal operating temperature.
8. Apply 1"-3" of vacuum to the venturi vacuum sensing line. The EGR valve should begin to open. This can be seen by watching the EGR valve stem or by a sudden rough idling

or stalling of the engine. If the EGR valve does not open, follow these steps.

9. Connect the hand vacuum pump to the EGR valve.
10. Apply 10"-12" of vacuum to the EGR valve.
11. If the valve does not open - replace the EGR valve.
12. If the valve does open, disconnect the vacuum line going to the bottom connection of the CTO switch and install a vacuum gauge.
13. Connect the hand vacuum pump to the venturi sensing line and apply 1"-3" of vacuum.
14. If a vacuum reading is present on the gauge this tells you that vacuum is available to the CTO switch. With a warm engine the CTO switch should be open to allow vacuum to the EGR valve. If vacuum is available to the CTO switch but is not getting to the EGR valve, replace the CTO switch.

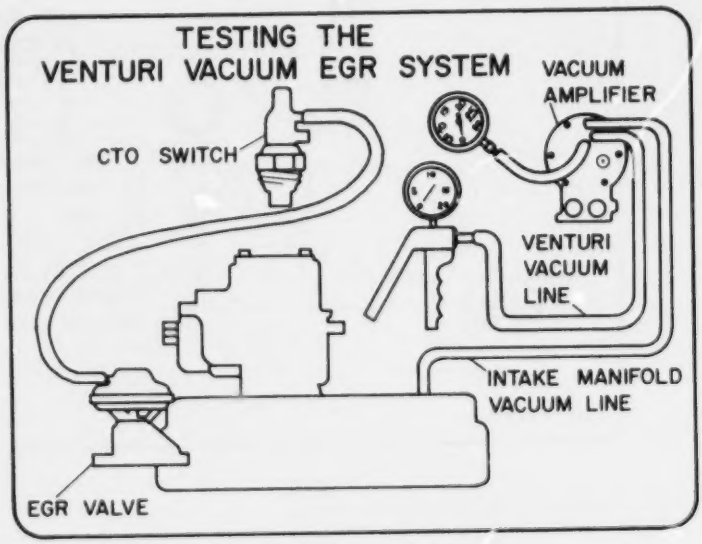

FIGURE 5-34

If no vacuum is available to the CTO switch replace the vacuum amplifier.

TESTING THE BACK PRESSURE SENSOR EGR SYSTEM

The following procedure can be used to test the back pressure sensor EGR system.

1. Start with a cold engine.
2. Disconnect the vacuum line at the EGR valve and install a tee and vacuum gauge. Reconnect the vacuum line to EGR valve.

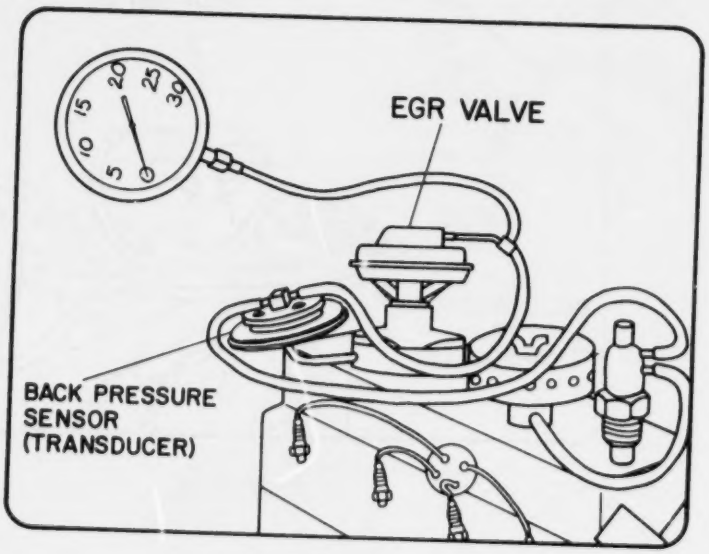

FIGURE 5-35

3. Start the engine and check the vacuum gauge. It should read 0".
4. Accelerate the engine to 2000 RPM. The vacuum gauge should read 0" of vacuum. With the engine coolant temperature low the CTO switch should be blocking vacuum to the back pressure sensor and EGR valve.
5. Allow the engine to warm up to normal operating temperature.
6. Accelerate the engine to 2000 RPM. If the CTO switch is open and the back pressure sensor is operating the vacuum gauge should read between 1"-4" of vacuum. If the gauge reads 0" of vacuum, follow the following procedure.

7. Follow the vacuum line that comes from the top connection of the CTO switch and goes to the exhaust back pressure sensor.
8. Disconnect the vacuum line at the back pressure sensor and install a vacuum gauge.

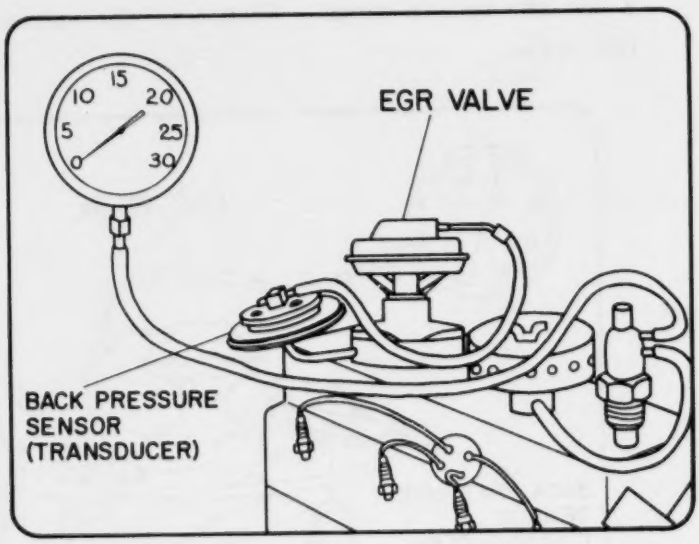

FIGURE 5-36

9. Accelerate the engine to 2000 RPM and watch the vacuum gauge. If there is no reading on the vacuum gauge, the CTO switch is not operating properly. Replace the CTO switch. If a vacuum reading appears on the gauge, the exhaust back pressure sensor is not operating properly.
10. Remove the back pressure sensor and check the exhaust pressure signal tube for restrictions. If the signal tube has carbon and/or lead deposits, a spiral wire brush can be used to clean this area.
11. Re-install the exhaust back pressure sensor.
12. Re-connect the vacuum lines making sure they are installed correctly.
13. Re-install the vacuum gauge with a tee at the EGR valve.

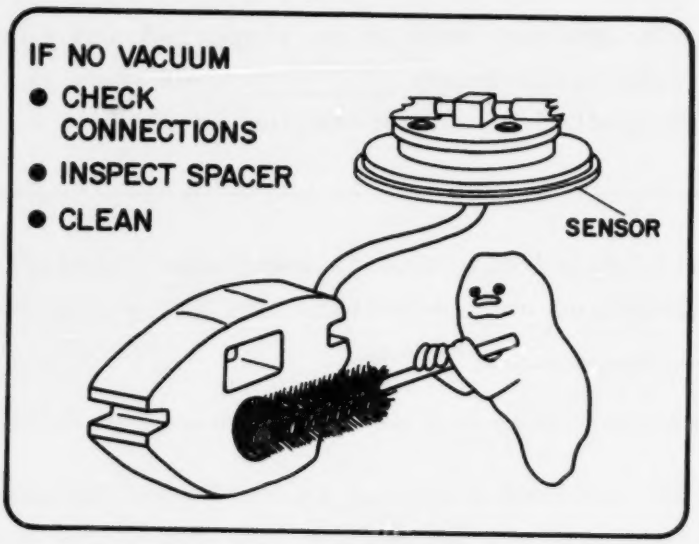

FIGURE 5-37

14. Start the engine and allow it to come to normal operating temperature.
15. Accelerate the engine to 2000 RPM and watch the vacuum gauge. If there is no vacuum reading on the gauge the back pressure sensor is not operating properly. Replace the exhaust back pressure sensor, as it connot be serviced.

    NOTE: Cars with single exhaust systems use a different back pressure sensor than cars with a dual exhaust system. Be sure the one you are going to install is the proper sensor. If a dual exhaust sensor is used on a car with a single exhaust system this will cause a driveability problem.

    A dual exhaust sensor operates at a lower back pressure. If this sensor is used on a vehicle with a single exhaust system it will result in too much exhaust gas recirculation. This will cause a large drop in engine power and fuel economy.

52. EGR systems should be inspected and tested anytime the vehicle is being _____, or when the EGR system is suspected of not operating properly.

53. If leaded gasoline is used most manufacturers recommend removing and inspecting the EGR valve every _____ miles.

54. If unleaded gasoline is used most manufacturers recommend removing and inspecting the EGR valve every _____ miles.

55. The CTO switch is not operating properly and should be replaced if the EGR valve begins to open while the engine is _____.

56. The CTO switch should be open to allow vacuum to the EGR valve with a _____ engine.

57. With the engine coolant temperature low the CTO switch should be blocking _____ to the back pressure sensor and EGR valve.

60. A dual exhaust sensor operates at a _____ back pressure than a single exhaust sensor.

SYSTEM SUMMARY

PURPOSE

The purpose of the exhaust gas recirculation system is to supply, in the proper proportion, inert exhaust gas to the air/fuel mixture in the intake manifold. This dilution of the air/fuel mixture reduces peak flame temperatures during combustion and reduces the amount of oxides of nitrogen (NO_x) in the exhaust.

MAIN COMPONENTS

EGR Valve - Meters or shuts off exhaust gas flow to the air/fuel side of the intake manifold.

Intake Manifold - Contains specially cast exhaust passages that connect to the intake side of the manifold through the EGR valve.

Carburetor Signal Port (on ported vacuum controlled EGR) - Located in the carburetor throttle body to sense manifold vacuum and control the EGR valve.

Venturi Vacuum Signal Tap (on Venturi Vacuum controlled EGR) - Located on carburetor throat to sense venturi vacuum signal. This signal is transmitted through a vacuum amplifier to control manifold vacuum to regulate the EGR valve.

Temperature Controlled Vacuum Valve - Prevents vacuum from reaching and operating the EGR valve until radiator top tank temperature reaches approximately 16°C (60°F).

SYSTEM FUNCTION

In order for the EGR system to operate, a manifold vacuum signal must reach the EGR valve. Vacuum can be sensed and directed to the EGR valve between idle and full throttle engine operation. The EGR system will not operate at idle or full throttle - only between these two conditions. However, a vacuum signal cannot reach the EGR valve under any conditions until the radiator top tank temperature or engine coolant temperature has reached

approximately 60°F. This assures good cold engine driveabiltiy. When in operation, the EGR system will divert a regulated amount of exhausted gases from the exhaust manifold back into the intake manifold to be mixed with the fresh air/fuel charge. This process reduces combustion temperatures and helps eliminate oxides of nitrogen (NO_x) from auto emissions.

ANSWERS

1. exhaust
2. exhaust
3. nitrogen
4. 2500°F
5. inert
6. lower
7. NO_x
8. Exhaust Gas Recirculation
9. intake manifold
10. valve
11. vacuum
12. no
13. port
14. venturi
15. zero
16. increases
17. coolant temperature override
18. coolant temperature
19. vacuum
20. ambient
21. EGR
22. venturi
23. intake manifold
24. pressure
25. vacuum
26. exhaust
27. surge
28. high
29. prevent
30. 35 seconds
31. vacuum solenoid
32. timer control or delay timer
33. closed
34. spring
35. valve
36. air/fuel
37. sealed
38. two
39. carburetor
40. intake manifold
41. ported
42. acceleration
43. NO_x
44. ball
45. open
46. intake manifold
47. high
48. ported vacuum
49. testing
50. service manual
51. vacuum
52. tuned up
53. 12,000
54. 25,000
55. cold
56. warm
57. vacuum
58. lower

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